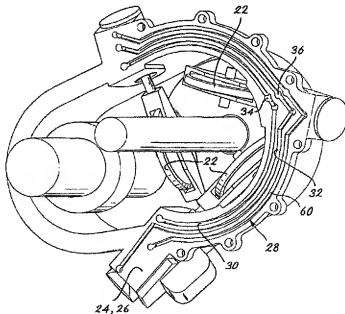




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(54) Title: HYDRAULIC SUPPLY FOR INFINITELY VARIABLE TRANSMISSION



(57) Abstract

The present invention relates to the supply of hydraulic actuation and cooling fluid to the roller actuation pistons and rollers provided in an IVT. The IVT assembly (10) includes a split casing (12a, 12b) and a manifold (28) that comprises one or more channels (30, 32, 60) formed in a surface of the casing formed by said split. The provision of said manifold in this position allows for easier manufacture and better performance.

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HYDRAULIC SUPPLY FOR INFINITELY
VARIABLE TRANSMISSION

5 The present invention relates to infinitely variable transmissions (IVT's) and relates particularly, but not exclusively, to the supply of hydraulic actuation and cooling fluids to the roller actuation pistons and rollers provided therein.

10 Presently known IVT's, such as that disclosed in GB-A- 2260583 comprise a pair of input disks and a pair of output disks mounted on a common axis X in order to define a pair of toroidal cavities in which are situated a plurality of variable position rollers employed to transmit motion between the input and the output disks. The rollers are hydraulically controlled by means of double acting hydraulic control pistons which employ the higher and the lower pressures within an associated hydraulic circuit to control the position of the rollers within the variator. In some arrangements, one roller
15 within each toroidal cavity set forms the master roller and the remaining rollers are similarly provided with hydraulic fluid and form slave rollers, the orientation of which follows that of the master roller. In other arrangements two rollers within each cavity are employed as the master rollers. The master and slave rollers in each cavity are equi-spaced around an outer diameter in a manner well known in the art and shown in
20 Figure 2 of the present invention.

The supply of hydraulic fluid to the master and slave rollers presently requires the outer casing of the IVT to be provided with the various passages which must be precision cast, drilled, cross-drilled or otherwise machined. Alternatively, expensive and
25 vulnerable external piping may be required.

In some applications it may be difficult to provide the complex network of hydraulic passages whilst meeting the desired cost, accuracy and performance requirements. Additionally, the friction losses within individual passages often varies depending on
30 the length, surface finish and straightness of each passage. In some cases this could result in different pressure drops along the said passages and in different pressures

being supplied to each roller control piston, thereby compromising the precision of the roller control system.

- 5 It is an object of the present invention to provide an IVT assembly which reduces and possibly eliminates the problems associated with the above-mentioned arrangement.

Accordingly, the present invention provides an IVT assembly comprising an outer casing and a plurality of hydraulically operated roller control pistons supplied with hydraulic fluid from a source thereof, via an hydraulic supply manifold, characterised
10 in that said outer casing comprises a split casing and in which the supply manifold comprises a channel within a surface of the casing formed by said split.

- Advantageously, the supply manifold comprises two channels, for carrying fluid at pressure, both of said channels being operably connected to one or more of said pistons
15 for the supply of fluid thereto.

Preferably, the first, and the second pressure channels are radially displaced relative to each other.

- 20 Advantageously, the supply manifold further includes a lubrication channel, for supplying lubrication within the IVT.

Advantageously, the lubrication channel is radially outward of said first, and second channels.

- 25 In a preferred arrangement the IVT comprises two pairs of input and output disks, each pair having sandwiched therebetween a plurality of rollers operably connected to said hydraulically operated roller control pistons, in which the pistons of each input/output disk pair are paired for the purpose of hydraulic fluid supply with a corresponding
30 piston for the other input/output disk pair.

In the particularly advantageous arrangements the pistons of one or more paired pistons are on opposite sides of said split line.

Advantageously the pistons of one or more paired pistons are equi-spaced from the split line, thereby to facilitate maintenance of substantially the same pressure drop within the manifold

In one arrangement the manifold comprises channels formed in one or both of the faces formed by said split in the casing.

In an alternative arrangement the manifold comprises channels formed in just one of the faces formed by said split in the casing.

In certain arrangements, it might be desirable to include a sealing member, such as a gasket, between the faces of the casing.

Conveniently, one or more of the channels includes an extension portion extending into said casing and away from an associated surface thereof, thereby to connect said channel with an appropriate portion of the hydraulic control piston.

Conveniently, the longitudinal axes L of the pistons are angled at an angle θ relative to the plane P of the split in the casing.

The present invention will now be more particularly described by way of example only with reference to the accompanying drawings, in which:

figure 1, is a part cut-away view of an IVT casing in accordance with the present invention;
figure 2, is a cross-sectional view taken in the direction of arrows B-B in figure 1;
figure 3, is a cross-sectional view taken in the direction of arrows X-X in figure 2;

figure 4, is a detailed cross-sectional view of the twin piston/roller arrangements of the above figures; and
figures 5 and 6 are cross-sectional views of alternative forms of the present invention.

5
Turning now to the drawings in general, but more particularly to figures 1 and 2, an infinitely variable transmission (IVT) 10 according to the present invention comprises an outer casing 12 having two portions 12a, 12b and matching pairs of input and output disks 14, 16, best seen in figure 4. The surfaces 18, 20 of the disks in each pair are
10 profiled thereby to define a toroidal cavity therebetween and in which are situated a plurality of rollers 22, best seen in figures 2, 3 and 4. Thus far the IVT is conventional save for the fact that the casing is split into two halves in a plane P which passes between the two output disks and which, in a preferred arrangement, divides the casing into two substantially equal portions 12a, 12b. The split line of the casing effectively
15 forms two mutually confronting surfaces 24, 26 which are, in the present invention, used to form an hydraulic supply manifold shown generally at 28 and best seen in figure 3. The manifold 28 comprises two or more channels 30, 32 within one or more surfaces 22, 24 which, between them, form the hydraulic fluid supplies. In one example the channels 30, 32 may be cast into the surface of the casing 12.
20 Alternatively, they may be formed by simply milling a slot in the surface in a manner well known to those skilled in the art and, therefore, not described herein. In either form, the channels 30, 32 effectively form a central manifold 28 into which hydraulic fluid is supplied by inlets 34, 36 under pressure from a source thereof, shown schematically at 35, and from which hydraulic fluid is taken to the master 38, 44 and
25 slave pistons 40, 42 and 46, 48, best seen in figures 1 and 2. Conveniently, corresponding pistons of each side of the variator are arranged back-to-back as shown in figures 1 and 4 such that the hydraulic fluids may be supplied to the appropriate piston chambers 50, 52 by means of simple drillings 54, 56 best seen in figure 4. Alternatively, where convenient the simple drillings may be replaced by a locally
30 deepened section of the channel 30, 32 formed by, for example, plunge milling or formed in the original casting. By arranging the pistons close to the split line, as shown in figure 4, it will be possible to minimise the depth of the drilling and, thereby reduce

the friction losses therealong. Additionally, the arrangement helps minimise the number of corners within the fluid supply and, hence, reduces the pressure losses within the supply. Further, it may be possible to make the channels 30, 32 somewhat larger in cross-section than presently known internally drilled passages, thereby reducing still further the friction and, hence, losses in the supply.

The two casing portions 12a, 12b of the above arrangement are bolted together by means of bolts 54 best seen in figure 1. Once bolted the surfaces 24, 26 mate up against each other to form a sealing surface which prevents the escape of hydraulic fluid from said manifold 28. In a preferred arrangement the channels 30, 32 are radically displaced relative to each other as shown and a significant sealing surface is provided therebetween, thereby to minimise the chance of any fluid escaping from the casing. In the event that pressurised fluid does escape from channel 30, it will be directed either inwardly towards the disks where it will be recirculated back to the sump (not shown) or outwardly towards the second pressure channel 32 which will receive it and prevent further escape. In such an event, the pressures within the channels will vary with time and, once detected, repair can be effected before a significant problem occurs.

In the arrangements of figure 4, the channels 30, 32 are formed on both surfaces 24 and 26. It will, however, be appreciated that the channels could be formed in just one surface or indeed on opposite surfaces, if so desired. In some arrangements it may be desirable to provide some form of a gasket or sealing member (not shown) between the two surfaces 22, 24.

If desired, the manifold might further include a lubrication channel 60 for supplying lubrication fluid to the rollers 22. This channel is conveniently formed in the same manner as described above in connection with channels 30, 32 and is preferably placed radially outward (outboard) of the other channels, as shown in figures 3 and 4. Lubrication fluid is usually at a lower pressure than either of the other fluid supplies and this positioning of the lubrication channel 60 provides a further barrier against possible fluid escape from the other channels. As shown, the lubrication fluid is

supplied to the manifold 60 via inlet 61 and passed from the manifold to a drilling 62 and thence to a rear supply chamber 64. Chamber 64 feeds the roller 22 via a central supply duct 66 formed through the piston and the roll support arm 68.

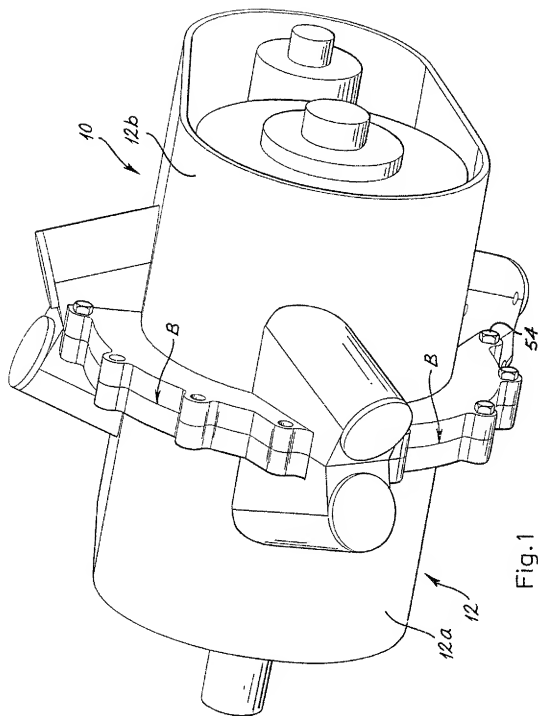
- 5 Operation of the above arrangement is conventional in as much as hydraulic fluid is supplied under pressure to inlets 34, 36 and delivered to the appropriate piston chamber 50, 52 by means of the manifold 28. Some particular advantages of the present arrangement have already been highlighted herein. It is, however, worth noting that the present arrangement does provide a simple, easy to assemble and compact arrangement
- 10 that reduces and possibly eliminates some of the problems associated with the prior art arrangements. Additionally the assembly is much simpler to machine than presently known arrangements. For example, one casing can be machined on a single machinery fixture employed for drilling/milling of holes and if necessary slits/channels as all of these operations would be perpendicular to faces 22, 24. The cylinder bores can also be
- 15 machined on a single fixture having three jig positions rotatable 120° about the variator axis, thus ensuring better precision of manufacture.

- Alternative forms of the present invention are shown in figures 5 and 6 from which it will be appreciated that the casing may be split in one or more of a number of different
- 20 positions. For example, figure 5 illustrates an arrangement where the casing is split at two end positions and end plates 80, 82 seal the casing and manifold channels 30, 32, 60. The angular position of the roller assemblies remained angled relative to the split line as described above. However, in this arrangement, the split line comprises the line L₁ which lies in the plane P of the joint. Operation of this arrangement is substantially
- 25 the same as disclosed in connection with the above embodiments with the exception of the fact that hydraulic fluid is now supplied to two manifolds rather than one. The further arrangement of figure 6 illustrates that the split line for one of the piston sets may be central to the actual casing whilst the split line for the second set of pistons may be at the end of the casing.

CLAIMS

1. An IVT assembly comprising an outer casing and a plurality of hydraulically operated roller control pistons supplied with hydraulic fluid from a source thereof, via
5 an hydraulic supply manifold, characterised in that said outer casing comprises a split casing and in which the supply manifold comprises a channel within a surface of the casing formed by said split.
2. An assembly as claimed in claim 1 in which the supply manifold comprises two
10 channels, for carrying fluid at pressure, both of said channels being operably connected to one or more of said pistons for the supply of fluid thereto.
3. An assembly as claimed in claim 2 in which the first and the second pressure channels are radially displaced relative to each other.
- 15 4. An assembly as claimed in claim 2 or claim 3 in which the supply manifold further includes a lubrication channel, for supplying lubrication within the IVT.
5. An assembly as claimed in claim 4 in which said lubrication channel is radially
20 outward of said first and second channels.
6. An assembly as claimed in any one of claims 1 to 5 in which the IVT comprises two pairs of input and output disks, each pair having sandwiched therebetween a plurality of rollers operably connected to said hydraulically operated roller control
25 pistons, in which the pistons of each input/output disk pair is paired for the purpose of hydraulic fluid supply with a corresponding piston for the other input/output disk pair.
7. An assembly as claimed in claim 6 in which the pistons of one or more paired piston are on opposite sides of said split line.
- 30 8. An assembly as claimed in claim 7 in which the pistons of one or more paired pistons are equi-spaced from the split line.

9. An assembly as claimed in any one of claims 1 to 8 in which the manifold comprises channels formed in one or both of the faces formed by said split in the casing.
- 5 10. An assembly as claimed in any one of claims 1 to 8 in which the manifold comprises channels formed in just one of the faces formed by said split in the casing.
11. An assembly as claimed in claim 9 or claim 10 and further including a sealing
10 member between said faces.
12. An assembly as claimed in any one of the preceding claims in which one or more of the channels includes an extension portion extending into said casing and away from an associated surface thereof, thereby to connect said channel with an appropriate
15 portion of said hydraulic control piston.
13. An assembly as claimed in any one of the preceding claims in which the longitudinal axes L of the pistons are angled at an angle θ relative to the plane A-A of the split in the casing.
20
14. An IVT assembly substantially as described herein with reference to figures 1 to 6 of the accompanying drawings.



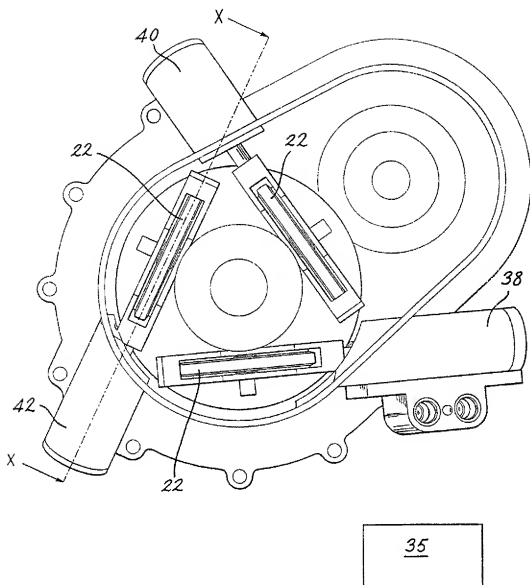


Fig. 2

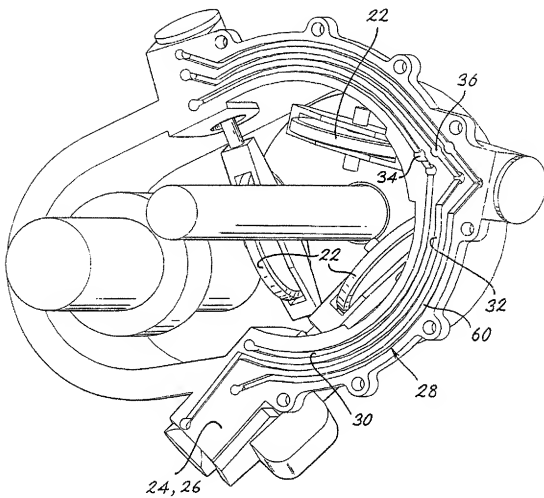
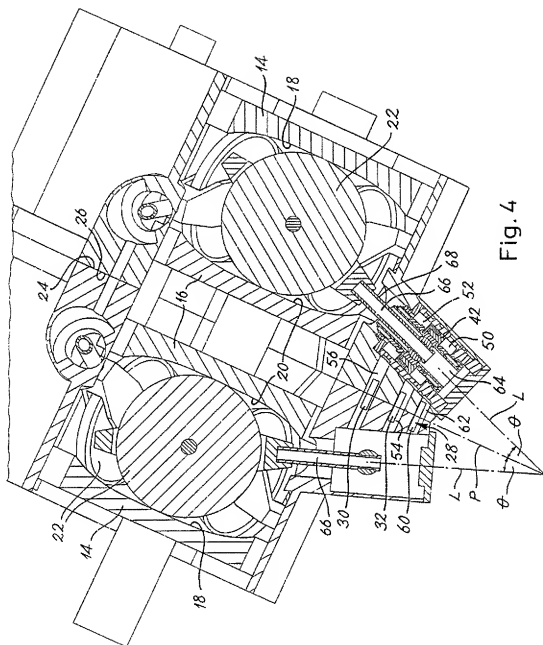


Fig. 3



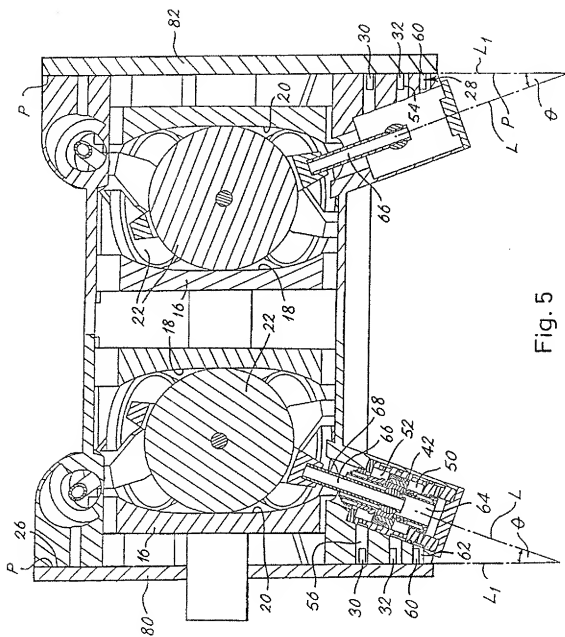
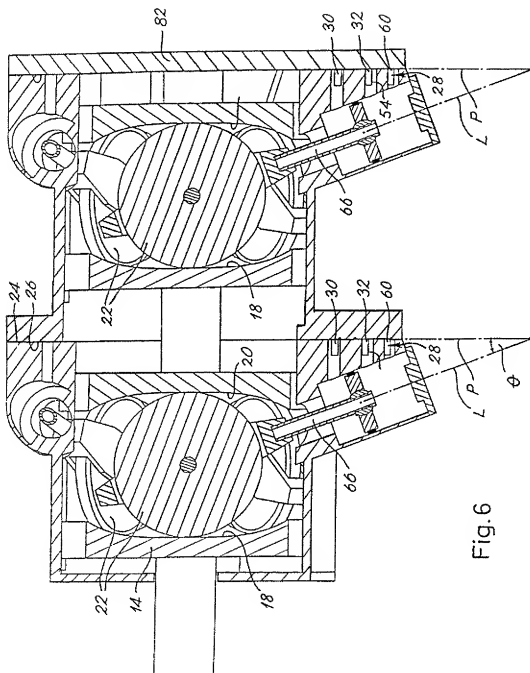


Fig. 5



INTERNATIONAL SEARCH REPORT

International Application No.

PCT/GB 99/02968

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F16H15/38

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 F16H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR 937 893 A (THE MASTER ELECTRIC COMPANY) 30 August 1948 (1948-08-30) figures 5-7	1
A	WO 92 01175 A (TOROTRAK DEV LTD) 23 January 1992 (1992-01-23) cited in the application figure 2	1
A	DE 34 18 552 A (JÄHNEL KESTERMANN GETRIEBEWERK) 21 November 1985 (1985-11-21)	

☐ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 99/02968

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